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AUTHOR Shepardson, Daniel P.; Adams, Paul E.
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ABSTRACT

Few studies have investigated the knowledge and beliefs that undergirds science teachers' assessment practice. This study was conducted to investigate the perspectives of science teachers on classroom assessment, considering the constructs that inform teachers of their classroom assessment practice. The study was grounded in a socioconstructivist theory that posits that teachers construct their own understandings and beliefs within the contexts of their own school cultures. The 12 middle-level (grades 4 through 9) teachers studied were all from the Midwest and all participants in a National Science Foundation teacher enhancement project on laboratory instruction and alternative assessment. Interview data were collected through a self-questioning technique. These data suggested that teachers understood the purposes of assessment as means of evaluating student performance and informing pedagogy, although the latter purpose was mentioned by relatively few teachers. If teachers view assessment from these two perspectives, then their motivation for assessment is primarily based on the learner and is seen as aligned with instruction or is pedagogically motivated. Teachers will adopt alternative assessment if it is seen to be compelling in terms of learner needs. (Contains 6 figures and 11 references.) (SLD)

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Perspectives on Assessment in Science: Voices from the Field

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DANIEL SHEPARDSON

TO THE EDUCATIONAL RESOURCES
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Daniel P. Shepardson

and

Paul E. Adams

School Mathematics and Science Center
Department of Curriculum & Instruction
1442 LAEB
Purdue University
West Lafayette, IN 47907-1442

shepards@vm.cc.purdue.edu

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Perspectives on Assessment in Science: Voices from the Field

Introduction

Although few studies have been conducted in science education on assessment, those studies that have been conducted have investigated teacher practice; that is, the approach science teachers take to assessing student performance. Such studies have investigated the formats teachers use to assess students (e.g., paper-pencil, performance based), the student abilities assessed by teachers and their assessment practice (e.g., factual understandings, process skills), and the cognitive level of assessment questions (e.g., recall questions, analysis questions). Few studies, however, have investigated the knowledge and beliefs that undergirds science teachers' assessment practice.

Stiggins, Frisbie, and Griswold (1989) have compared teacher assessment practice to the recommendations put forth by the measurement community concerning grading, the purpose for most classroom assessment. A synthesis of their findings suggest: 1) some teachers consider the ability level of students, with higher expectations for high-ability students; 2) student effort is often considered or weighted in assessment; 3) daily assignments were often inconsistently assessed; 4) teachers collect more assessment data than necessary, with the assessments often treated in a summative form and of questionable quality; and 5) most assessment instruments are not well developed, thus questioning the reliability and validity of the information obtained. Although Stiggins et al. (1989) have described the assessment practice of teachers, it is unclear as to what factors inform teachers' about their assessment practice.

It has been identified elsewhere that the purpose for assessing students is for the improvement of science learning and instruction; conveying expectations to students, parents, teachers, and administrators; and for monitoring individuals, classes, districts, states, and the nation (Raizen, Baron, Champagne, Haertel, Mullis, & Oakes, 1989). Further, while standardized achievement tests have political clout, they fail to inform classroom practice or inform practice in such a way that promotes the notion of teaching to the test. In either case, teachers' view standardized assessment with a different purpose that likely does little to challenge their knowledge and beliefs about assessment, as well as their pedagogical approach. Stiggins, Conklin, and Bridgefor (1986) have stated that standardized assessment has little influence on the quality of instruction or learning in schools. These assessment purposes fail to recognize the teachers' perspectives about assessment and the knowledge and beliefs that inform their classroom assessment practice. It is also essential to understand how teachers' knowledge and beliefs about assessment inform their assessment practice: not only what is assessed, but how it is assessed and why.

Purpose of Study

Assessment in science education is currently receiving much attention, with an emphasis on reforming assessment practice, enhancing accountability, and improving achievement. There has been, however, little attention focused on science teachers (Doran, Lawrenz, & Helgeson, 1994), their knowledge, beliefs, and perspectives about assessment. Therefore, the purpose of this study was to elucidate science teachers' perspectives about classroom assessment practice. Specifically:

- What constructs inform science teachers about their classroom assessment practice?
- How do these constructs interact to inform science teachers about their classroom assessment practice?
- What is the structure of these constructs?

The significance of this study lies in its investigation of teachers' knowledge and beliefs about assessment practice. Further, the findings have direct implication to the preparation and enhancement of science teachers, by elucidating the understandings and beliefs science teachers hold toward classroom assessment practice.

Theoretical Framework

This study is grounded in a socioconstructivist theory that posits that teachers construct their own understandings and beliefs about assessment in science within the context of the culture of their school and classroom. Further, teachers' construct understandings and beliefs about assessment through social interactions with others--peers and students. Lastly, teachers' prior knowledge and experience influence their understandings about assessment in science. Thus, an aspect of any study on teacher knowledge, grounded in a socioconstructivist theory, is to identify what the teacher already knows about assessment in science and how to best represent this understanding (cf. Tobin, Tippins, & Gallard, 1994).

Method

The study was qualitative in that it consisted of conducting interviews with teachers on their assessment practice. The interviews were conducted with middle level (grades 4-9), science teachers who were participants in a NSF teacher enhancement project on laboratory instruction and alternative assessment. The teachers were participating in their second summer of the project.

Participant Selection

The 12 participants interviewed represented the diversity of the group of 30 teachers in the project based on years of experience, science preparation, grade level, and perceived teaching skill. The 12 teachers were all from the Midwest. A subset of four in-depth cases were purposefully selected from the 12 interviews for finer analysis in order to better understand the teacher's purposes, knowledge, and beliefs related to assessment. DE, an experienced middle school teacher has used alternative assessment and student-centered teaching strategies throughout his career. JH is an experienced teacher who feels constrained by her school district to cover content. SR, a beginning teacher, has consistently used cooperative group teaching strategies from the outset of her career. RG is an experienced teacher who taught science through rote methods until his involvement with the NSF teacher enhancement project; he now makes extensive use of student-centered teaching and assessment methods.

Data Collection

Data for this study was collected through use of the Self-Q (self-questioning) technique (Richardson & Simmons, 1994; Bougon, Baird, Komocar, & Ross, 1990) and in-depth interviews. The Self-Q is a method to have "participants reflect on their experiences in the [classroom], . . . identify, extract, and construct important concepts . . . and impose relationships among these concepts" (Richardson & Simmons, 1994, p. 53). From these reflections a feedback map, a map in which "meaningful variables in the participant's environment are identified and linked to one another through causal relations" (Richardson & Simmons, 1994, p. 54) is constructed. The purpose for using this method was to see if assessment was a meaningful variable for the teachers; if so, then it would arise naturally from the analysis of the data. The Self-Q procedures were as follows:

(1) The 30 participants in the project generated as many responses as possible to the question: "What are the questions you ask yourself as you go about your daily activities as a classroom teacher?" The teacher generated lists of questions were rewritten into the form of a declarative statement by the researchers. For example, "What questions should I ask my students?" was transformed into the declarative statement, "I plan the questions I will ask my students."

(2) The participants then verified the declarative statements; changes and additional statements were made as appropriate. The participants next identified the fifteen most important statements and ranked them in order of importance.

(3) These fifteen statements, or variables, were placed on a response sheet that facilitated rating the degree and direction (with a range of -3 to +3) of the effect of a variable on each of the other variables. This data was used to produce a feedback map that connected the strongest flows (+3 and -3; +2 and -2) between the variables (refer to Figure 1); the feedback map was constructed by the researchers.

(4) A unique interview guide (Patton, 1990), for the 12 key informants, was developed based upon the feedback map. The interview questions were designed to have the teacher elaborate on elements of the feedback map that exhibit the greatest number of connections.

Insert Figure 1 about here

Data Analysis

The interviews were transcribed verbatim. Methods of single and cross-case analytic induction (Patton, 1990) were combined to analyze the data. Three researchers analyzed the data to reduce the influence of bias and subjectivity, thereby increasing the validity of the analysis and interpretation of results (Patton, 1990). Each interview was first individually read by each researcher and the emergent patterns noted. Next, the researchers collaboratively discussed the interview data in light of the individually identified emergent patterns. Thirdly, the researchers collaboratively constructed categories based upon the emergent patterns, that were then imposed on to the data.

The interviews of the four in-depth cases were re-read in order to delineate the interrelationships between knowledge and beliefs of content, pedagogy, learners, and assessment. These four domains served as the foundation in the construction of the interrelationship maps. As a knowledge or belief construct was identified in the interview, it was placed on the map; connections were drawn to illustrate the manner in which the construct related to other constructs and to the four domains. As new constructs were added to the map, existing constructs were reassessed in relation to the interview data to determine if the original connections still remained valid. A second and third re-reading of the interviews were done to search for disconfirming evidence and to seek further construct elaboration. The inter-relationship map was summarized by a narrative illustrating how the relation between the purpose of assessment and the knowledge and beliefs that undergrid assessment was articulated in each of the four cases.

Results and Discussion

In order to present and discuss the findings of this study, we first present an overview of the teacher interview data for the purpose of elucidating and describing the emergent categories. We next present four case narratives, constructed from the interview data, to further elucidate the richness of these teachers' perspectives about assessment and the interrelationship between assessment, pedagogy, content, and learners.

General Findings

Based upon the interview data, these science teachers' understand assessment from the purpose for assessment and the knowledge and beliefs that undergrid their assessment practice (see Figure 2). These teachers talk about the purpose of assessment as being for the evaluation of students and for the informing of pedagogy. The teachers also talk about assessment as being undergrid by their knowledge and beliefs about pedagogy, content, and/or the learner. Their perspective about the learner can be categorized as: beliefs about learner abilities or beliefs about learner outcomes. Further, their descriptions

of assessment activities may be categorized as either formal and alternative in nature, formal and traditional in format, or as informal approaches to assessing students.

Insert Figure 2 about here

Purpose for Teachers' Assessment Practice in Science. These science teachers' explained the purpose for conducting assessment as a means for evaluating student performance and for informing pedagogy. Although some teachers' descriptions of assessment activities involved more than one purpose, evaluation of student performance was the dominant reason for assessing students; whereas the purpose for informing pedagogy was mentioned only by a few teachers.

Teachers who talked about the purpose of assessment as evaluation referred to assessment as a means for determining what knowledge or concepts students had learned or what skills students were able to perform. For example, VC states: "You know, test evaluations . . . did they learn . . . you know, seventy percent of the material." Not only does VC's statement emphasize assessment as evaluation, but an assessment approach that reflects a formal traditional method of assessment--tests.

Although VC describes a more traditional approach to assessment above, she also utilizes formal alternative assessment techniques to evaluate student understanding. For example, VC has her students perform resolution laboratories and develop computer simulations. Her resolution laboratories have students perform a chemical procedure in the laboratory and use their knowledge of chemistry to describe and interpret the data they collected. She also has students develop computer models to simulate their understanding of chemistry laboratories, as VC says ". . . okay, you did 'x' experiment in the lab . . . now I want you to make a simulation for me on the computer."

Although the predominant purpose for assessment is evaluation, these teachers also talk about assessment as a tool for informing pedagogy. Assessment as informing pedagogy is illustrated in RG's response concerning student cooperation:

"I'm looking at group cooperation a lot too, and if I do notice kids that can't work together, I try to make a conscious effort not to put them together again."

As with RG, many teachers referred to group cooperation when describing assessment as a means for informing pedagogy. Although RG used assessment of student cooperation to influence his pedagogical decisions concerning group composition, SR used assessment of student understanding prior to a laboratory activity to determine group composition:

". . . I did a pre-assessment [where] I asked them a question about how to do something. It was a lab we were getting ready to do and I asked them. 'How would you do this?' I . . . put them together on how they thought . . . alike . . . and it worked out pretty good."

SR's assessment as informing pedagogy is illustrated in her use of student ideas about designing and conducting a laboratory experiment to determine the group composition.

Unlike RG and SR, MB's assessment as informing pedagogy revolves around student understanding. For MB, if he informally observes that students are having difficulty understanding the science concept he interrupts the activity to address students' misunderstandings, as illustrated in the following statement: "I have to periodically stop the lab to say, 'Okay, this is what I see as a common problem.'" Thus, for MB, informally assessing students' understandings during the laboratory activity informs him of his next pedagogical move. While MB's pedagogical move is informed through assessing students, that is, his pedagogy is determined prior to his informal assessment; VC described using assessment to determine her pedagogical move prior to instruction. For VC, if assessment is to involve

students in performing a laboratory procedure or experiment, then students should have had prior instructional experience similar to the laboratory-based assessment:

"If you're going to come up with laboratory-based assessment, you know, of course they should have been doing laboratories that were somewhere in the ballpark of what you are going to ask them to do."

For these teachers, then, assessment is for the purpose of evaluating student performance and for informing pedagogy. Although specific references to assessment for evaluation varied in their degree of formality, assessment for evaluation was predominantly through formal approaches (82%), whereas specific references to assessment for informing pedagogy reflected formal approaches 69% of the time. Thus, these teachers tended to use more formal assessment for evaluation than for informing pedagogy.

Knowledge and Beliefs that Inform Teachers' Assessment Practice in Science. Although these science teachers viewed the purpose of assessment in science as for evaluation and for informing pedagogy, their assessment is driven by their knowledge and beliefs about pedagogy, content, and/or the learner. That is, assessment is constrained by their pedagogy, shaped by the content they teach, or influenced by their view of the learner--beliefs about learners and learner outcomes. Although pedagogy, content, and the learner are identified as separate categories, teachers often referred to more than one category as informing their assessment practice.

Assessment as assisting learners is characterized by assessment approaches that promote student learning or performance and are designed to accommodate student ability. For example, TL provides his students the opportunity to select the assessment activities that they feel most comfortable with; taking a traditional test, completing a study guide, or doing an expanded project. As TL says:

"... every kid has different problems and different strengths. ... so I set up a variety of activities [assessments] that they can chose from. ... there are things that kids with specific learning problems will have success with."

Whereas TL provides students the opportunity to select an assessment activity of their choice, VC and MB talk about assessment activities based upon student learning abilities:

"It's my concept that some students do well where you have to read and then produce an answer. Other students do not do well. They may know, they may know what they're doing. They may know the facts, but to have to read a question that you've written with your mind set, and then try to answer that question may not work well for them, because maybe their mind set or their way of learning or thinking is very different from yours. And so they can be confused by your word questions. And so I ... incorporated ... stations [where students would] go around the room and answer questions about them" (VC).

"I had a box, and they [students] drew out names [chemical compounds]. Build this compound and bring them to me. ... The type of learner, the type twos seemed to like that, nothing was written. ... [T]hen I turn around, and I set them up, and they [students] have to name them" (MB).

Both VC and MB also think of assessment as assisting learning by structuring assessment activities that play to the strengths of their students. For VC it is providing concrete experiences, stations, to assist students in learning and performing, which is based upon the view that her students "... are probably still, if you believe in Piaget, you know in concrete situation." On-the-other-hand, MB thinks of assessment as assisting learners through assessment activities that compliment the students' learning style.

The science content taught motivated teachers in terms of the assessment approaches they used to evaluate student performance. For example, JH talks about three ways in which the content taught motivated the way she assesses students. JH uses traditional, multiple choice tests as approaches to assessing students when the science content is viewed as vocabulary, terminology students should know; whereas if the science content is viewed as a skill, then the assessment approach used involves students performing the skill. Finally, JH describes using assessment approaches based upon the degree of abstraction of the science content, "... when it's really abstract I go to a more concrete kind of test... especially abstract things [atoms and molecules] I like them [students] to draw me [a] picture ... then explain the drawing." JH also talks about using problem-solving based laboratory assessments when the science content can be assessed through direct manipulation of phenomena. Here, JH described a problem-solving scenario wherein students are provided simple machines (pulleys, incline planes, and levers) and they are to "figure [the] mechanical advantage" to determine the best machine to solve the problem scenarios.

Assessment in science for these teachers was also motivated by pedagogy, the methods they used to teach determined how they assessed students. For example, when BM conducted demonstrations (she conducted demonstrations when safety or lack of materials were constraining issues), she assessed students by having them write answers to the questions she asked during the demonstration: "These are the things, and this is what I'm going to do, what do you think is going to happen?" "Why did it happen?" "Have you ever seen anything ... like this before?" Further, BM describes how her assessment approach changes based upon the degree her students are actively involved in the instruction. "... [T]he more physically the child personally had interaction with the material, the more I ... expect them to ... re-describe what happened ... to recall more and transfer more information." Thus, for BM, the more inquiry oriented the instruction the more problem-solving based and "real-life" the assessment becomes.

Case Narrative

In this section we present the four in-depth case narratives as a means for elucidating the interrelationships between teachers' knowledge and beliefs about assessment, pedagogy, content, and learners.

The Case of JH. For JH, assessment is for the purpose of evaluating learners' content, process, and social abilities or performances; and is guided by the content and pedagogy (see Figure 3). Further, JH's knowledge about assessment determines how she assesses her students. For example, JH uses observation and interactions with students as a means for assessing their social abilities (on task, cooperation), whereas performance laboratory activities and laboratory checklists are used to assess students' laboratory processes and performance capabilities. Content knowledge is assessed through the use of traditional assessment instruments (multiple choice), as well as through the use of more alternative assessment tasks such as drawing and explaining and interpreting data.

JH's content is driven by the school corporation and the state curriculum framework and testing procedure. As JH states:

"The academic goals [content, skills] ... tie into the curriculum ... [There are] some things that the administration has come very pointedly on, a few things that are tested on ISTEP. We have to teach electricity because there are questions about electricity on the ISTEP."

This content perspective informs JH as to the academic goals, that in turn interacts with her pedagogical knowledge to determine the instructional strategies she employs in her classroom:

"I kind of use the academic goals to choose my lab and ... the vehicle for getting that information across. ... I actually go out and search for a lab that fits the concepts that I want to get across. And the more abstract it is the more I try to find a concrete lab to go with it. ... I do jigsaw when it's kind of rote memorization."

JH also relies on her knowledge of learners to inform her pedagogical moves. That is, she moves to make science concepts "more" concrete for concrete operational learners and also integrates reading and lecture for students with more verbal based learning styles:

"We talk about learning styles and so I think that some kids . . . do better with lecture, the reading, and the book. . . . [However] some kids get more meaning from the lab. . . . When we're working with something that kids can't see I try to develop some models that they can use."

Thus, JH bases her instructional strategies upon her beliefs about learners. She uses instructional strategies that touch on all learning styles and approaches that "makes the abstract . . . more concrete."

Although JH's knowledge of the content and pedagogy is directly influenced by her beliefs about learners, her assessment practice is driven by the science content as determined by the school corporation and state testing procedure and by the pedagogy she utilizes to address the content. Knowledge about learners does not directly influence her assessment practice, as indicated in JH's statements:

"If a lot of vocabulary and if I feel that the vocabulary is important, then I do lower level, multiple choice kind of things [tests]. . . . If [students have] used a skill for example, reading a table, then I test that skill by giving the kids new information and ask them [to] put it into a table. . . . If I am looking for specific things [skills, during a laboratory] I use the . . . checklist. It makes it real easy cause it's either a plus, a check, or a minus or noting. . . . This way its what they're actually doing in lab, as well as the product of the lab."

JH's statements emphasize the importance of content (vocabulary and skills) as a driving force for her assessment practices--tests, checklists. As JH states, "The content really does influence the way I use and what tests I use." Knowledge about learners does not directly inform her assessment moves; however, her beliefs about learners indirectly links to assessment practice through the alignment of assessment with instruction.

JH's knowledge about assessment practice, however, allows her to utilize assessment approaches that are embedded into instruction, as well as multitrait. For example, JH uses student interactions and observations to assess students' social skills and laboratory checklists to assess students' process skills during laboratory activities. Further, she uses performance based laboratories whereby students are given a problem scenario to solve using laboratory equipment, applying science concepts to explain their solution. These assessment approaches, then, allow JH to assess multiple student traits--social and process skills and content. Her use of performance laboratories, performance tests, and traditional multiple choice tests at the conclusion of an instructional unit also allows her to assess students content knowledge, conceptual understandings, and process skills. This assessment practice, then, allows JH to assess multiple student traits using multiple sources of assessment.

Insert Figure 3 about here

The Case of SR. SR, a novice teacher, classroom practice is structured around collaborative groups and guided by her belief that the science content taught should be relevant to the daily lives of her students: ". . . before I teach I have to feel like something is important for them" (see Figure 4). The content that SR feels is relevant to students, then, influences the instructional strategies she employs, ". . . the content definitely influences what I'm doing." Further, SR values collaborative group learning, thus grouping strategies contribute to her overall instructional approach and are embedded into her instruction. SR, however, believes that the more abstract the content the less successful group learning is: "If things are more abstract and harder for them to see, then group work may not necessarily work." Thus, SR does not use group work when concepts become more abstract, which for her entails concepts not directly accessible through the observation of phenomena.

SR, at times, uses pre-assessment activities to inform her pedagogy, grouping strategy:

"I did a pre-assessment based upon what they [students] did . . . I asked them a question about how to do something. It was a lab we were getting ready to do and I asked them, 'How would you do this?' I kind of put them together on how they thought . . . alike . . . it really worked out pretty good."

SR also used assessment activities to inform her pedagogy. For example, SR's students had just completed a series of population activities and the assessment activity involved them in a field study; however, as SR found out from the assessment, ". . . I realized that some of their ideas, what they were writing down . . . and . . . doing [that] they didn't get it." As a result of the assessment activity, SR designed a new laboratory activity concerning populations, that addressed the students' lack of conceptual understanding. Thus, SR uses assessment activities that are seamless to instruction and that inform her pedagogy, to determine her next pedagogical move.

Student learning abilities also influence SR's assessment approach. Because SR's classroom is an inclusive classroom, she adjusts her assessment approach to reflect the learning abilities of her students. For example, SR describes a situation with one special education student:

"So his evaluation I would do totally different because I couldn't evaluate him the same way I would evaluate the others. I would maybe evaluate on his group participation, if he was writing things down and listening . . . He was a student that was working at the 3rd grade level and could never get any to the concepts we were talking about."

The purpose for instruction not only influences SR's instructional strategies, but determines what is assessed. Further, the instructional strategies SR uses determine how she assesses her students, aligning assessment with instruction. The nature of the science content also influences the assessment approach that SR utilizes in her classroom, as SR states:

"[A] lecture . . . would be assessed differently [than] a hands-on kind of [activity]. So, it depends on the content and what its about and how easily it lends itself to different kinds of assessment."

Although SR's purpose (content and social goals) and instructional approach determined what or how she assessed students, she at times referred to the Indiana State Proficiency Guide to ensure that she was assessing her students based upon the state proficiencies. If SR felt that she had not assessed students based upon the state proficiencies, she identified which proficiencies she needed to assess students:

"I'll go back and . . . look at what's on there [State Proficiency Guide] and what types of things I haven't evaluated or what things I hadn't seen from them [students] . . . [and] if I need a particular type of evaluation."

Thus, for SR, the purpose for assessment is both for informing pedagogy and evaluating students' learning. The knowledge and beliefs which frame SR's assessment practices are drawn heavily from pedagogical perspectives, with knowledge and beliefs about learners taking a supporting and indirect role in her assessment practice.

Insert Figure 4 about here

The Case of DE. DE's knowledge and beliefs about teaching and learning are founded on his belief that the purpose of teaching is for students to learn how to solve "real problems" and integrate science into their lives (see Figure 5). His beliefs about pedagogy serve as the filter in his decisions

related to learners, pedagogy, content, and assessment. DE related the following in connection of how he might choose a topic:

"Well, for example, the first one, my main goal, 'learn to solve problems,' and then 'learn to become more aware of the science that is a part of their lives,' those are the two main goals. Then when I have a topic that I feel I'm suppose to cover based on our curriculum guide or some aspect of it, I will look at it in terms of how I will teach it and what relationships it has to those two goals. . . if it does not relate to one of my goals then I don't do it."

DE indicated not only did he use his goals to guide in the selection of topics but also as a guide to the type of activities that he would have his students do in class.

DE's knowledge of learners is controlled by his belief that students need to be successful and accomplish the activities that are part of the day-to-day operation in his classroom. Success in DE's estimation is multifaceted. It involves accomplishing a task that is appropriate for their skill level, enjoying the task, and learning and understanding the concepts. As DE relates:

"I've always found the kids may say they want to have fun, but they also want to feel as if they are accomplished students in school. And by simply having fun, they end up walking out and saying, 'What did we do?' and 'We did nothing, we messed around and wasted our time.' They may have a good time, but they perceive it as a waste of time. Whereas if they feel they've learned something, they feel very good about themselves, even if it was a lot of hard work."

This belief about students and learning is a filter that DE uses in choosing instructional strategies.

DE's knowledge of content is driven by his personal experiences, his research, and classes that he has taken over his career as a teacher. It is interesting that he strongly believes in being the final authority as to the content in his classroom. DE stated the following to explain his choice of curriculum:

"I have yet to find a good curriculum that matches what I think is important based on my experience, my own research, classes I've taken and so on. So therefore I develop my own curriculum."

DE, as indicated in the quotation, has clearly taken responsibility for his own professional development. His experiences have empowered him to feel justified in deciding what is most appropriate for his students in his classroom.

DE's knowledge of pedagogy is difficult to separate from his knowledge of assessment and his knowledge of content. For him these three areas are nearly seamless since all of these are means to fulfill his beliefs about pedagogy; in essence these have become part of his semantic memory and are not easily separated or recalled. In relation to knowledge of pedagogy, however, his most explicit concern was with sequencing instruction to develop pre-requisite process skills necessary for students to succeed. As DE relates:

"Some kids come into class in the 8th grade and be reasonable problem solvers. Many do not have those skills. Basic skills for observation; recording information; being critical listeners, critical observers; trying to develop some sort of reasonable hypothesis, as opposed to just a guess. That's a major step for these kids. And then developing a conclusion that is based on both their hypothesis and whatever data they accumulated, instead of simply a 'how do you feel about it' kind of conclusion. Through out the year I continue to build on increasing their different skills necessary to become good problem solvers."

It is evident that DE is very focused on his students needs. The quotation also illustrates how his beliefs about pedagogy provide direction to the sequencing of the course and the actions he chooses to do in the classroom.

DE's knowledge of assessment is seamless with his instructional strategies. The distinction between instruction and assessment is relative to the role he assumes in the classroom. For DE, instruction occurs when he is actively helping students construct their knowledge, by interacting with them as they work on class projects. As DE states:

"I consider any form of assessment something in which I am not in the position to help them come up with the answer. So if they can solve, or come up with the answers on their own at that point, then I am assessing what they know. Prior to that time, when they have my assistance, then we're in a learning state."

The learning state that DE identifies can be typified as an informal assessment in that students interact with him to check their understanding, whether this be through class discussion or doing laboratory activities. Further, the students may be asked to construct a project as part of the activity; a type of performance assessment. Instructional activities are also designed to strengthen students' process skills.

DE's classroom actions and assessment decisions are strongly driven by his beliefs about pedagogy, that is the purpose of teaching is that students learn. He achieves this goal by making instruction seamless with assessment. DE, for example, provided students up to a week to solve a problem related to electrical circuits (a performance based assessment), not only was this the assessment but it was also the learning activity. As DE states "I always consider any evaluation to be a learning experience." DE, by drawing on his experiences, provides his students with a variety of innovative and attention-grabbing activities that form not only the bases for instruction but for assessment as well. For DE the purpose of assessment is not only evaluation but for learning; his knowledge and beliefs about pedagogy provide the filter through which his decisions are made.

Insert Figure 5 about here

The Case of RG. For RG, assessment is for the purpose of evaluating the outcomes of specific learning strategies. RG's choice of learning strategies are guided by his knowledge and beliefs about students: science learning should be "hands-on," students should learn to work collaboratively in groups, and students progress through developmental levels. RG has developed his knowledge of assessment in response to his adopting a student-centered model of learning which he has attributed to his involvement with the project. RG strives to match his assessment strategies with his instructional strategies (see Figure 6).

RG's knowledge and beliefs about learners are driven by his belief that learning should be hands-on. RG's conviction towards hands-on materials was arrived in part due to an action research project he conducted in his classroom. The purpose of the project was to compare an alternative assessment strategy to a traditional assessment strategy on a topic of the teacher's choice. As RG relates:

"I approached it from the hands-on activities first, and then to see what they knew at the end. And the other group, I approached it from the textbook and then went into the lab and let them verify etc. And I found that approaching it with hands-on first, the kids had a better understanding when we were done and were able to answer the questions in more detail and further understanding than the ones that we started with the book first and did the labs last."

RG also uses his knowledge of the developmental level of learners to select appropriate content and teaching strategies. As RG relates:

"At the end of the school year I did the roller coaster activity on motion. On my level, I was trying to get the concept across that the marble is only going as high as the previous hill. It can't go any higher without an additional force behind it. Whereas, on a higher level, I might have done things like velocity--have them figure out the formulas and so forth. But that would not have been appropriate on my level."

RG's knowledge of pedagogy is directly influenced by his belief about learners, as the previous quotation illustrates. Guided by his knowledge of learners he has constructed his pedagogical knowledge on a foundation of hands-on learning and group work. His pedagogical knowledge is used as a filter in making instructional decisions. Closely associated with the decision of an instructional strategy is the choice of assessment. For RG the instructional strategy dictates the choice of assessment. The following quotation from RG illustrates this point:

"If I were just reading and lecturing, it [the assessment] would simply be a written test at the end. And by using the different methods--hands-on or whatever--it lends itself to different kinds of evaluations. And you can evaluate more aspects of it, not just, 'Do they understand the concept?' but, 'Have they developed the skills necessary to work together in a group?' 'Have they learned to answer all sections of the lab data sheet?' You know, all the different things you evaluate somewhere along the way."

This clearly illustrates RG's stance that the assessment strategy should align with the instructional strategy. RG has made use of assessment strategies such as projects, informal and formal checklists, reports, and laboratory sheets to assess his students; it is his belief in associating pedagogical decisions to assessment decisions that directly impacts his assessment choices. RG makes use of multiple assessment strategies to assess multiple traits of his students -- from understanding to being able to work in a group, in accordance with his beliefs about students.

Insert Figure 6 about here

Conclusion

Although Tobin and Gallagher (1987) described teachers' purpose for assessment as a means of motivating students to actively participate, cooperate, and complete instructional activities, these teachers perceived the purpose of assessment in science as for informing pedagogy and evaluating students. Thus, if teachers view assessment in science from these two perspectives, then their motivation behind assessment is predominantly based upon the learner and seen to either be aligned with instruction or seamless to instruction--pedagogically motivated.

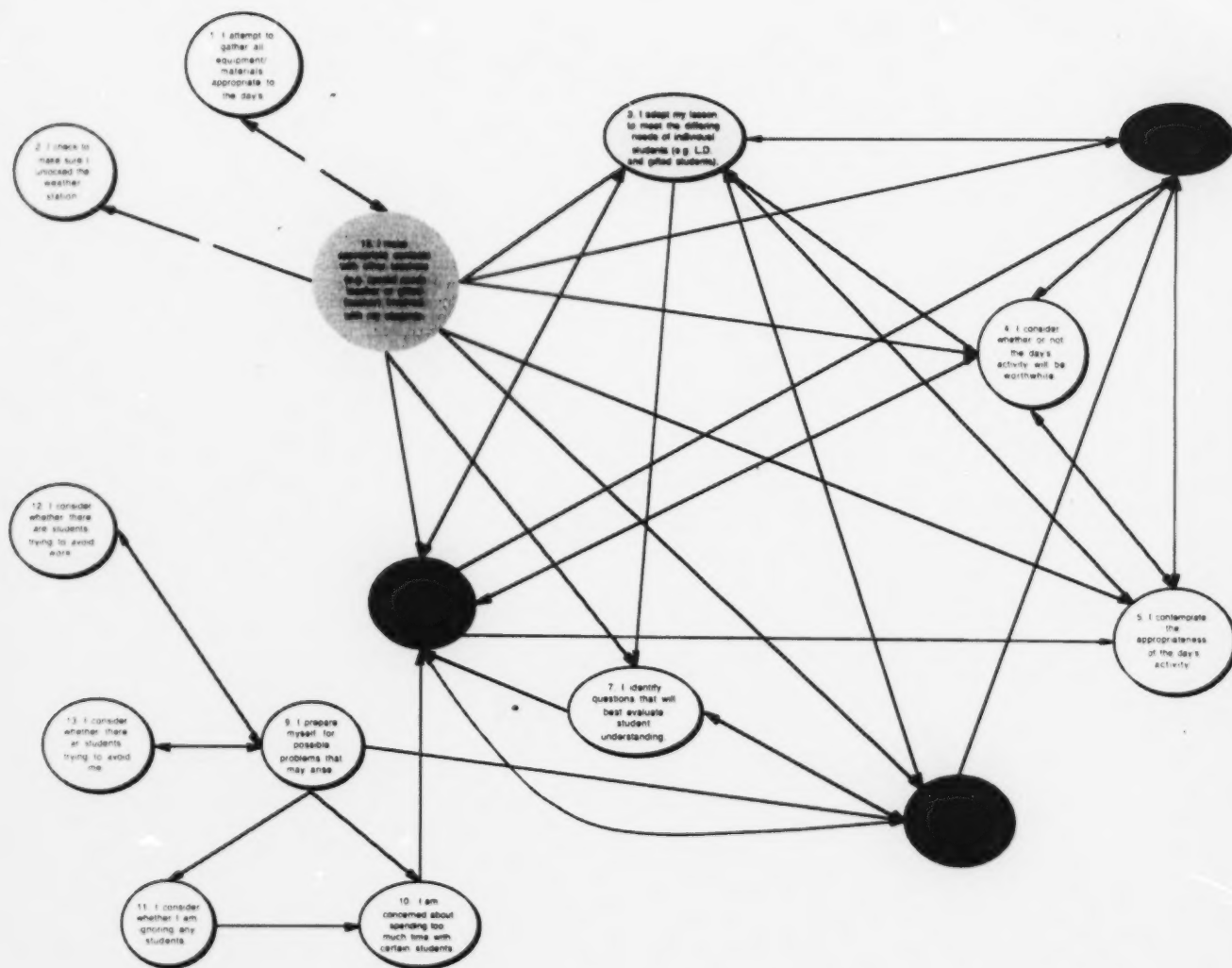
Examination of the diagrams and teacher commentary support the contention that teachers view beliefs as knowledge (Grossman, Wilson, & Shulman, 1989); that is, teachers treat their beliefs about learners as knowledge that informs their pedagogy and assessment practice. The implication for teacher preparation and enhancement, then, is that the teacher's "knowledge" of learners provides a framework for what is appropriate pedagogy and assessment. Thus, preservice courses or inservice workshops need to address assessment and pedagogical issues from the perspective of learners, integrating knowledge of learners, pedagogy, content, and assessment. For alternative assessment to be adopted by teachers, it must be compelling in terms of learners. Such appears to be the case of RG, JH, and SR; DE has already constructed an alternative assessment framework based upon his knowledge and beliefs about learners. Each of these individuals (RG, JH, and SR) appears to have adopted facets of the project in accordance with their prior knowledge. RG has extended his assessment practice in accordance with the change in

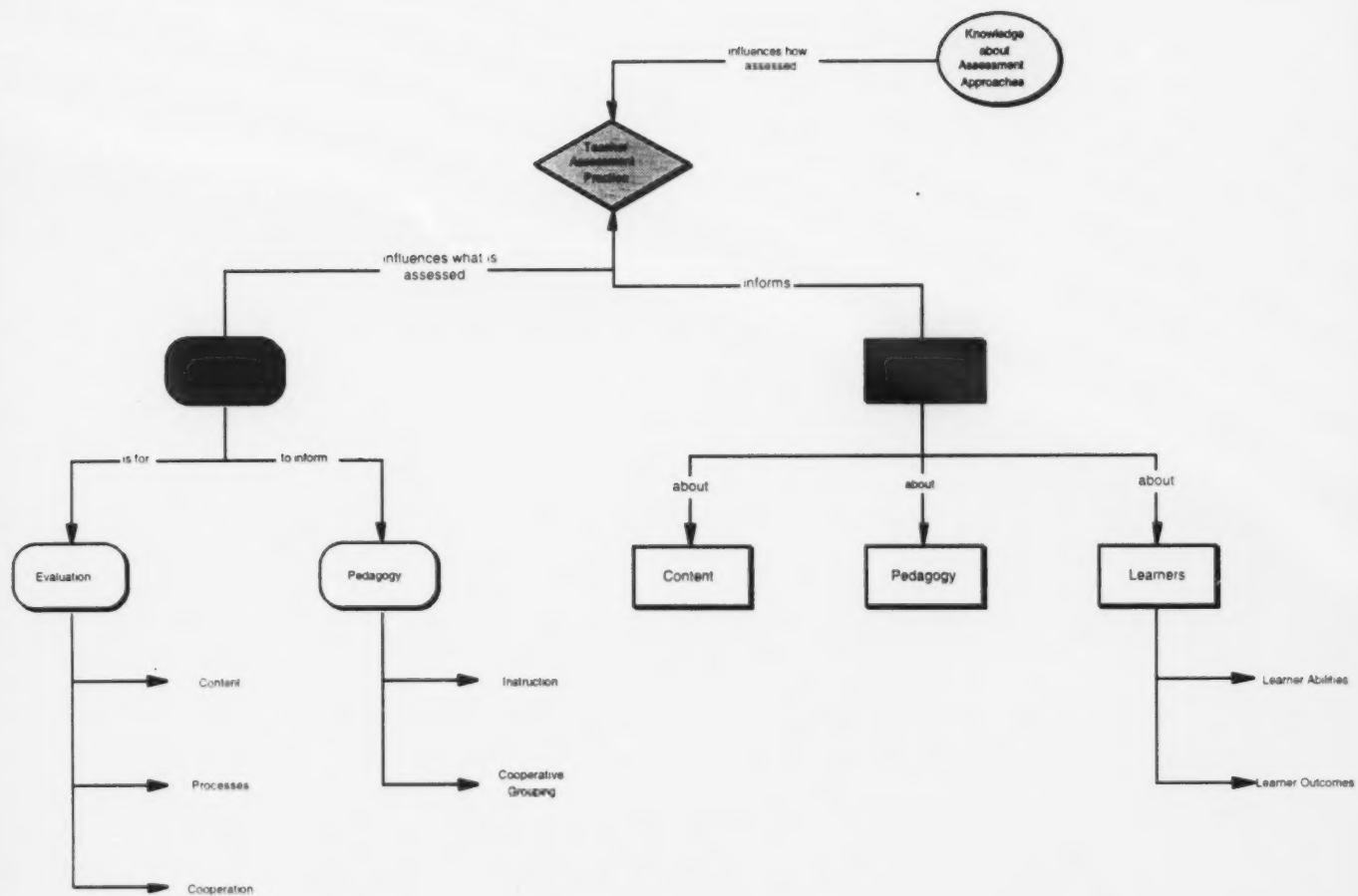
his instructional strategy, JH has adopted assessment techniques that align with her views about learners and content, and SR's assessment techniques are seamless to instruction as they are aligned with her views about learner abilities and content relevant to learners.

Lawrenz and Orton (1989) in a survey of seventh- and eighth-grade science teachers found that teacher assessment practice emphasized multiple-choice, true-false, short essays, and written definition tests as a means to evaluate students, suggesting an emphasis on science content. It appears from the teachers in this study, then, if the motivation for assessment in science emphasizes the learner and pedagogy, the factual science content becomes less of a factor in assessing students and the assessment tasks become more alternative or authentic in nature. The research implication, then, based upon these teacher voices is the need to investigate how preparation in alternative assessment in science assists teachers in constructing understandings of the interrelationship among learners, pedagogy, and content; pedagogical-content-assessment knowledge.

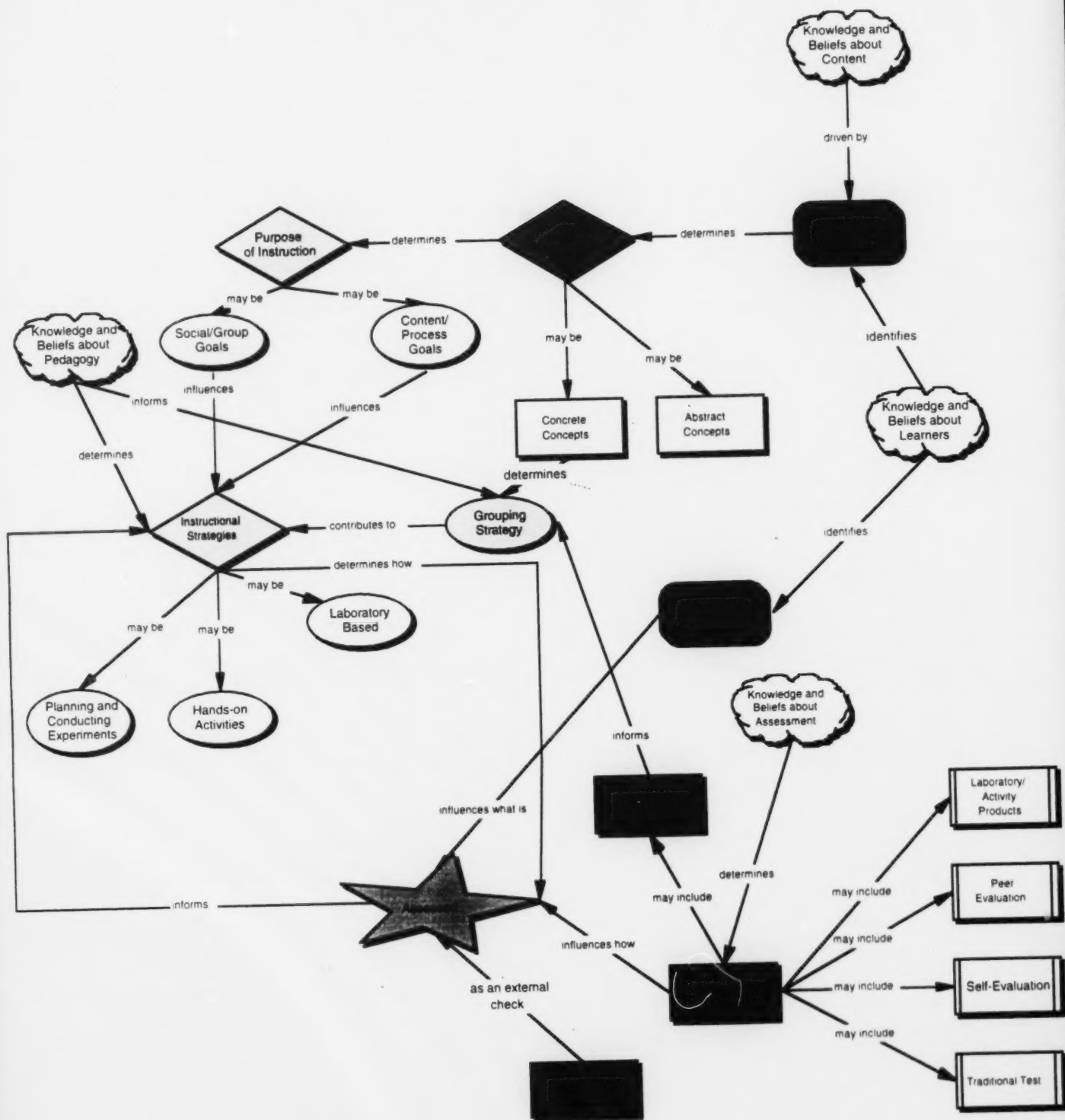
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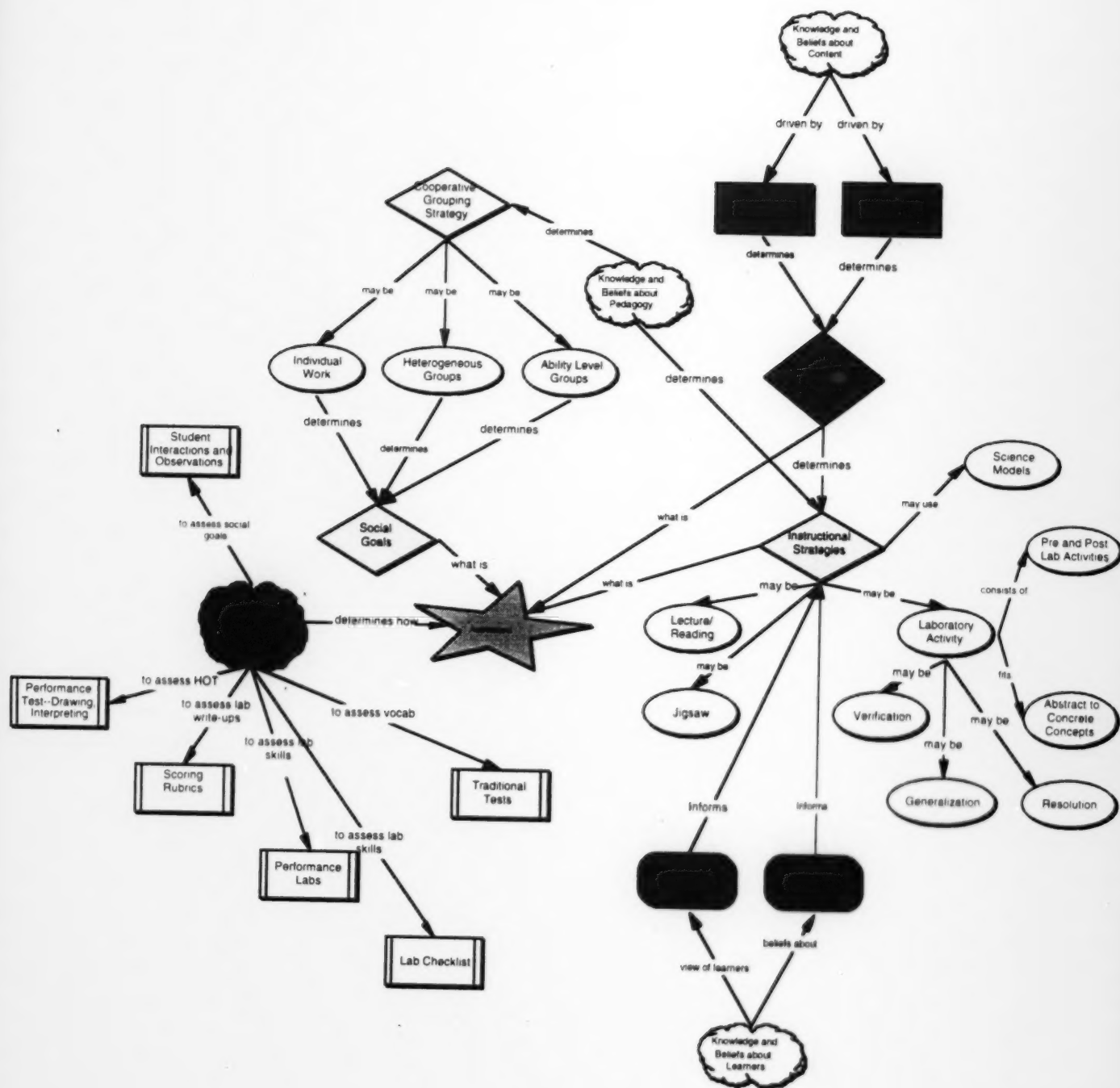
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